PUBLISHER-SUBSCRIBER

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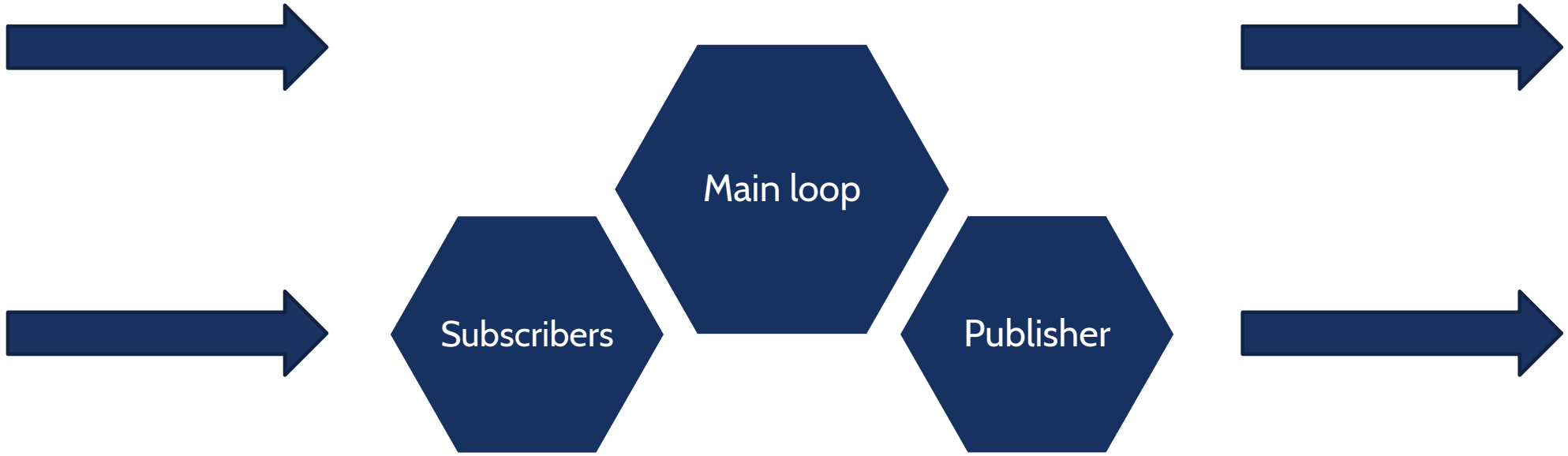
INSIDE THE NODE



WRITING A PUBLISHER NODE

First create a package inside you src folder:

$ catkin_create_pkg pub_sub std_msgs rospy roscpp

Next cd to the new pub_sub/src folder and create a c++ file:

$ gedit pub.cpp

WRITING A PUBLISHER NODE

First write some includes:

```
#include "ros/ros.h"
#include "std_msgs/String.h"
#include <sstream>
```

WRITING A PUBLISHER NODE

We are still writing c++ code, so we have to write a min function

```
int main(int argc, char **argv)
{

}
```

All the code for the publisher node will be written inside this function

WRITING A PUBLISHER NODE

As previously explained the first thing to do when we write a ROS node is call ros::init():

```
ros::init(argc, argv, "pub");
```

And next create a node handle:

```
ros::NodeHandle n;
```

WRITING A PUBLISHER NODE

Now we create a publisher object:

```
ros::Publisher chatter_pub = n.advertise<std_msgs::String>("publisher",
1000);
```

We have different way to create a spinner in ROS, but in this case we want to control the loop frequency:

```
ros::Rate loop_rate(10);
```

WRITING A PUBLISHER NODE

Next we write the main loop:

```
while (ros::ok())
{
}
```

while (ros::ok()) is just a better way to write while(1), it'll handle interrupt, stop if a new node with the same name is create or a shutdown command is called

WRITING A PUBLISHER NODE

Before calling the publisher node we create our message:

```
std_msgs::String msg;
    std::stringstream ss;
    ss << "hello world ";
    msg.data = ss.str();
```

The type of the message, as shown during the publisher creation is std_msgs::String

WRITING A PUBLISHER NODE

Now that we have a message we can call publish it:

```
chatter_pub.publish(msg);
```

Last we call:

```
loop_rate.sleep();
```

which will wait until the time previously specified has passed, and then restart the loop

WRITING A PUBLISHER NODE

Before compiling our code we have to add it to the CMakeLists.txt file

It already has some code, generated by the create_package command; first add at the end of the file:

```
add_executable(publisher src/pub.cpp)
```

to add the new file we have created

WRITING A PUBLISHER NODE

Then add:

```
target_link_libraries(publisher ${catkin_LIBRARIES})
```

to specify the correct library, and:

```
add_dependencies(publisher pub_sub_generate_messages_cpp)
```

to specify the dependencies from message generation

Now we can cd to the root of the workspace and compile our code using:

```
$ catkin_make
```

WRITING A PUBLISHER NODE

If everything went well you can start roscore:

```
$ roscore
```

and start your node:

```
$ rosrun pub_sub publisher
```

you can check the published topic with:

```
$ rostopic echo /publisher
```

WRITING A SUBSCRIBER NODE

The subscriber node has a similar structure to the publisher, create a file called sup.cpp:

```
#include "ros/ros.h"
#include "std_msgs/String.h"
int main(int argc, char **argv)
{

 ros::init(argc, argv, "sub");
 ros::NodeHandle n;
}
```

WRITING A SUBSCRIBER NODE

But this time inside the main function we create a subscriber object

```
ros::Subscriber sub = n.subscribe("/publisher", 1000, pubCallback);
```

where pubCallback is the name of the callback function called every time a new message is received

WRITING A SUBSCRIBER NODE

We are also not interested in cycle at a predetermined speed, so we will simply call:

```
ros::spin();

  return 0;
```

ros::spin() will simply cycle as fast as possible calling our callback when needed, but without using CPU if there is nothing to do

WRITING A SUBSCRIBER NODE

Now we can write our callback function

```
void pubCallback(const std_msgs::String::ConstPtr& msg)
{
  ROS_INFO("I heard: [%s]", msg->data.c_str());
}
```

the argument of the function is a pointer to the received message, in our case a std_msg::String

WRITING A SUBSCRIBER NODE

As we did with the publisher node we have to add it to the CMakeLists.txt file:

```
add_executable(subscriber src/sub.cpp)
target_link_libraries(subscriber ${catkin_LIBRARIES})
add_dependencies(subscriber pub_sub_generate_messages_cpp)
```

Now we can compile it and test the two nodes together

LAUNCH-FILE

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LAUNCH FILE

When working on big project it's useful to create a launch file which with only one command will:

-start roscore

-start all the node of the project together

-set all the specified parameters

To create a launch file cd to the pub_sub package and create a launch folder

$ mkdir launch

LAUNCH FILE

Inside the launch folder create a launcher.launch file

the launchfile is a XML file, the root tags are

<launch></launch>

inside these tags you can start all your nodes using:

```
<node pkg="package" type="file_name" name="node_name"/>
```

when we started a node from the command line we used:

$ rosrun package file_name

the name attribute allow us to specify inside the launch file the name of the node

LAUNCH FILE

We can also regroup some nodes under a specific namespace using the tags:

```
<group ns="turtlesim1"></group >
```

Namespaces allow us to start multiple node with the same name, because they lives in different namespace

Sometimes we may need to change some topics name without changing directly the package code, to accomplish this task we use:

```
<remap from="original" to="new"/>
```

LAUNCH FILE

Inside the launchfile paste this code:

```
<launch>

  <group ns="turtlesim1">
    <node pkg="turtlesim" name="sim" type="turtlesim_node"/>
  </group>

  <group ns="turtlesim2">
    <node pkg="turtlesim" name="sim" type="turtlesim_node"/>
  </group>

  <node pkg="turtlesim" name="mimic" type="mimic">
    <remap from="input" to="turtlesim1/turtle1"/>
    <remap from="output" to="turtlesim2/turtle1"/>
  </node>

</launch>
```

LAUNCH FILE

This code starts two turtlesim and connect them together, the command from cmd vel to turtlesim1 will be redirected also to turtlesim2

But we still have to run in a new terminal window the teleop_key node

So we also have to add

```
<node pkg="turtlesim" name="control" type="turtle_teleop_key"/>
```

inside the turtlesim1 namespace

If we want to open a node in a new terminal we can add the attribute:

launch-prefix="xterm -e"

CUSTOM MESSAGES

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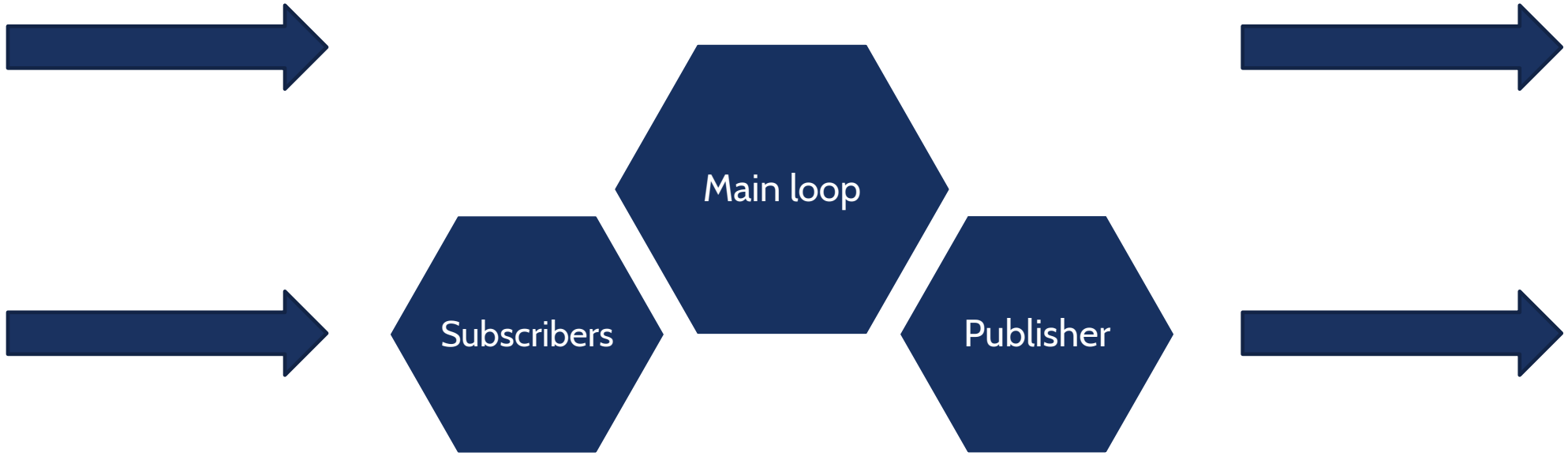
INSIDE THE NODE



CREATE A MESSAGE

Messages are saved in the msg folder of the package; first create the folder inside the pub_sub package:

$ mkdir msg

Next create the msg file:

$ echo "int64 num" > msg/Num.msg

CREATE A MESSAGE

Before using the new message we have to make sure they are converted into source code for c++, open the package.xml file and uncomment those two line:

```
<build_depend>message_generation</build_depend>
 <exec_depend>message_runtime</exec_depend>
```

CREATE A MESSAGE

Next we have to edit the CMakeLists.txt file, first add message_generation dependency to find_package

```
find_package(catkin REQUIRED COMPONENTS
  roscpp
  rospy
  std_msgs
  message_generation
  )
```

CREATE A MESSAGE

Then export the message_runtime dependency uncommenting the following call and adding message_runtime:

```
catkin_package(
  CATKIN_DEPENDS message_runtime
)
```

CREATE A MESSAGE

Last we have to add the message file and generate them, so uncomment the

“add_message_files” and “generate_messages” and add to the first our msg file

```
add_message_files(
 FILES
 Num.msg

 )
```

```
generate_messages(
   DEPENDENCIES
  std_msgs
 )
```

CREATE A MESSAGE

Now we can compile our code calling catkin_make in the root directory of the workspace and test if ros finds our new message calling:

```
$ rosmsg show pub_sub/Num
```

USING CUSTOM MESSAGES

To test our new message we will modify the publisher-subscriber nodes open the pub.cpp file

first we include the custom message adding:

```
#include "pub_sub/Num.h"
```

then we modify the publisher object, changing the type of the message:

```
ros::Publisher chatter_pub = n.advertise<pub_sub::Num>("publisher", 1000);
```

USING CUSTOM MESSAGES

Last we create a message of type pub_sub::Num and assign a number to the num field:

```
static int i=0;
i=(i+1)%1000;
pub_sub::Num msg;
msg.num =i;
```

Now we can compile our code and look at the published topic using:

```
$ rostopic echo /publisher
```

USING CUSTOM MESSAGES

The changes to the sub.cpp file are similar:

first include the new message

```
#include "pub_sub/Num.h"
```

Then change the type of the message received by the callback:

```
void pubCallback(const pub_sub::Num::ConstPtr& msg)
```

USING CUSTOM MESSAGES

Last update the print function:

ROS_INFO("I heard: [%d]", msg->num);

Now we can compile and test both the publisher and the subscriber

PARAMETERS

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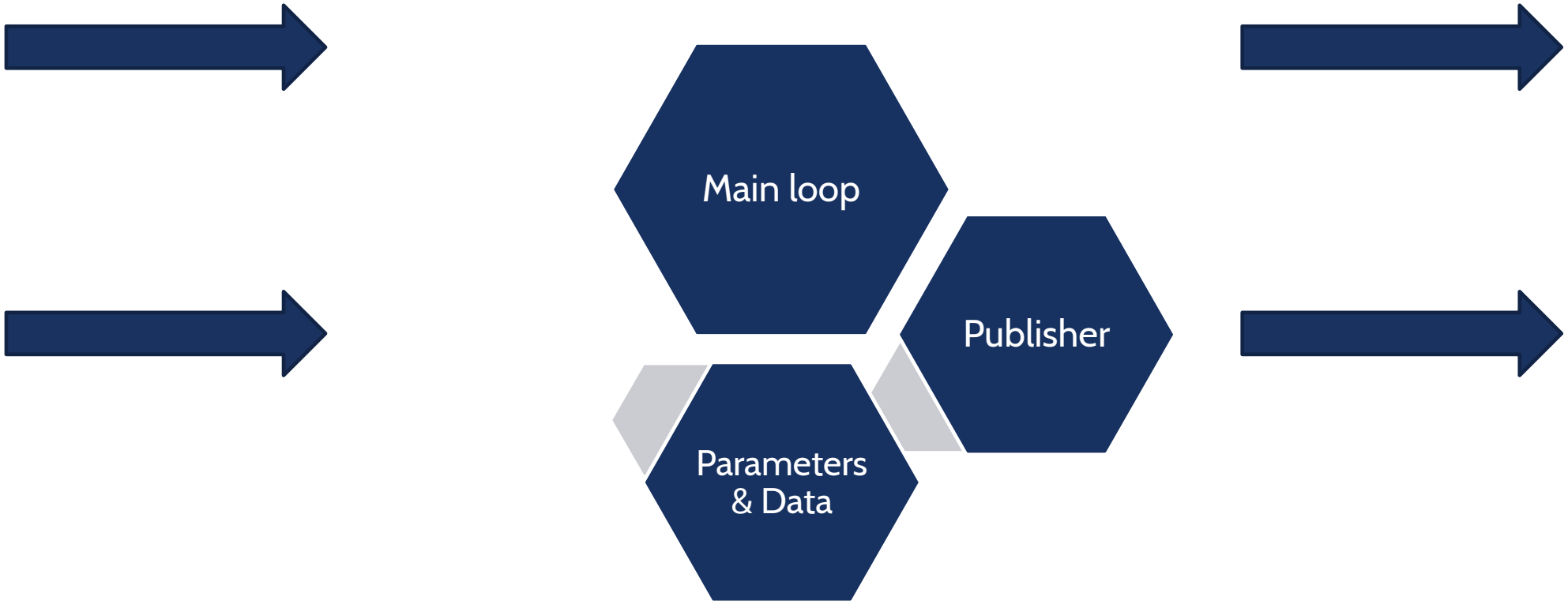
INSIDE THE NODE



USING PARAMETERS

2 ways to use parameters:

- Look at the value before entering main loop
- Add callback to parameters change

3 ways to set parameters:

- command line
- launch file
- rqt_reconfigure

PARAMETER CHECK BEFORE MAIN LOOP

Similar code tu publisher/subscriber example:

```
#include "ros/ros.h"
#include "std_msgs/String.h"

#include <sstream>
```

Standard include

PARAMETER CHECK BEFORE MAIN LOOP

Similar code tu publisher/subscriber example:

```
int main(int argc, char **argv){

    ros::init(argc, argv, "param_first");
    ros::NodeHandle n;

    ros::Publisher chatter_pub = n.advertise<std_msgs::String>("parameter",
1000);
    std::string name;
    (...)
```

ros initialization

Publisher creation

PARAMETER CHECK BEFORE MAIN LOOP

Similar code tu publisher/subscriber example:

```
n.getParam("/name", name);
```
← get parameter value

```
ros::Rate loop_rate(10);
```
← set loop rate

PARAMETER CHECK BEFORE MAIN LOOP

Similar code tu publisher/subscriber example:

```
while (ros::ok()){
        std_msgs::String msg;
      msg.data = name;
      ROS_INFO("%s", msg.data.c_str());
      chatter_pub.publish(msg);
      ros::spinOnce();
      loop_rate.sleep();

  }
```

Main loop, not different from previous example

PARAMETER CHECK BEFORE MAIN LOOP

Add the new file to CMakeLists.txt, as we did in pub/sub example

```
add_executable(param_first src/param_first.cpp)
target_link_libraries(param_first ${catkin_LIBRARIES})
```

Compile the new node

PARAMETER CHECK BEFORE MAIN LOOP

Start the node:

- If no parameter is previously set the node will publish an empty string
- Set the parameter value using: “ rosparam set name "first" ”
- Now the node will publish “first” string
- If you change again the value while the node is running it will have no effect because the node looks at the value only once

SETTING PARAMETER VALUE INSIDE THE LAUNCH FILE

A good practice with parameter is to set the value directly inside the launch file, so the user doesn't have to initialize the values using command line tools, add the line:

```
<param name="name" value="value" />
```

Inside a Launch file to set a parameter

SETTING PARAMETER VALUE INSIDE THE LAUNCH FILE

Create a param_set.launch file inside a launch folder

```
<launch>
 <param name="name" value="second" />
 <node pkg="parameter_test" name="param_first" type="param_first"
output="screen"
/>

</launch>
```

Set the parameter value

Redirect the output of ROS_INFO to the terminal

DYNAMIC RECONFIGURE

Previous examples allowed us to set the parameter value only once, to change the value while the node is running it's not recommended to insert the getParam call inside the mail loop because it's resource consuming and inefficient, to achieve this task we use dynamic reconfigure

DYNAMIC RECONFIGURE

First create a cfg folder and inside a parameters.cfg file, than make it executable:

```
chmod +x parameters.cfg
```

Now we can start writing the configuration file; cfg file are not written in c++ but in python

DYNAMIC RECONFIGURE

```
#!/usr/bin/env python
PACKAGE = "parameter_test"

from dynamic_reconfigure.parameter_generator_catkin import *

gen = ParameterGenerator()
```

Set the package of the node

Import for dynamic reconfigure

Create a generator

DYNAMIC RECONFIGURE

To add a parameter we use the command:

```
gen.add (“name”, type, level, “description”,default, min, max)
```

In our case:

```
gen.add("int_param",    int_t,    0, "An Integer parameter", 50,  0, 100)
gen.add("double_param", double_t, 0, "A double parameter",    .5, 0,   1)
gen.add("str_param",    str_t,    0, "A string parameter",  "Hello World")
gen.add("bool_param",   bool_t,   0, "A Boolean parameter",  True)
```

DYNAMIC RECONFIGURE

We can also create multiple choice parameter using enum, first create an enum using a list of const; to create a constant:

```
gen.const (“name”, type, value, “description”)
```

Than create the enum:

```
my_enum = gen.enum([const_1, cosnt_2, ...], “description”)
```

Last we add the enum like previously

```
gen.add (“name”, type, level, “description”,default, min, max, edit_method = my_enum)
```

DYNAMIC RECONFIGURE

In our case we create a size parameter with four values:

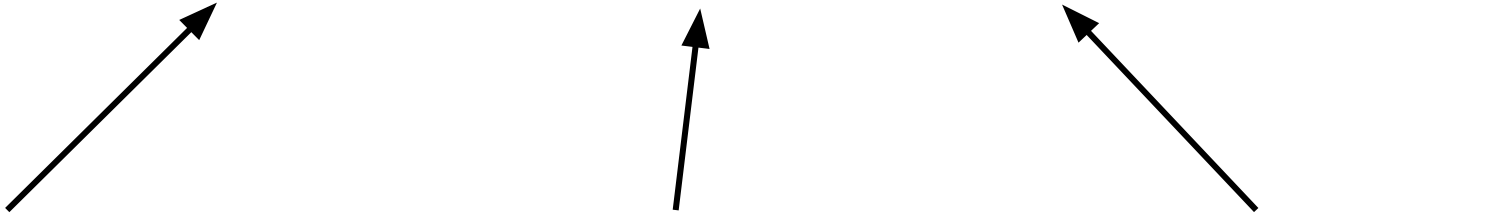
```
size_enum = gen.enum([ gen.const("Small",      int_t, 0, "A small constant"),
                       gen.const("Medium",     int_t, 1, "A medium constant"),
                       gen.const("Large",      int_t, 2, "A large constant"),
                       gen.const("ExtraLarge", int_t, 3, "An extra large
constant")],
                     "An enum to set size")

gen.add("size", int_t, 0, "A size parameter which is edited via an enum", 1, 0,
3, edit_method=size_enum)
```

DYNAMIC RECONFIGURE

Lastly we have to tell the generator to generate the files:

```
gen.generate(“package name”, "node_name", "prefix")
```



The prefix value is the string used to create the name of the header file you will have to include, with the name “`prefixConfig.h`”

DYNAMIC RECONFIGURE

In our case we write:

```
exit(gen.generate(PACKAGE, "param_second", "parameters"))
```

Now we can write a node using those parameters, create a file “param_second.cpp” in your src folder

DYNAMIC RECONFIGURE

```
#include <ros/ros.h>
#include <dynamic_reconfigure/server.h>
```

} Standard include

```
#include <parameter_test/parametersConfig.h>
```

← Include the previously generated file

DYNAMIC RECONFIGURE

```
int main(int argc, char **argv) {
  ros::init(argc, argv, "param_second");

  dynamic_reconfigure::Server<parameter_test::parametersConfig> server;

dynamic_reconfigure::Server<parameter_test::parametersConfig>::CallbackType f;
```

ROS initialization

Create the parameter server specifying the type of config

Create the callback

DYNAMIC RECONFIGURE

```
f = boost::bind(&callback, _1, _2);
```

← Bind the callback

```
server.setCallback(f);
```

← Set the server callback

```
ROS_INFO("Spinning node");
ros::spin();
return 0;
```

} keep spinning

DYNAMIC RECONFIGURE

```
void callback(parameter_test::parametersConfig &config, uint32_t level) {
```

Create the callback

Pointer to the parameters structure

Value of the level bitmask

DYNAMIC RECONFIGURE

Last we print all the parameters value

```
ROS_INFO("Reconfigure Request: %d %f %s %s %d",
            config.int_param, config.double_param,
            config.str_param.c_str(),
            config.bool_param?"True":"False",
            config.size);
```

DYNAMIC RECONFIGURE

We also have to edit the CMakeLists.txt, to the find_package call add: "`dynamic_reconfigure`"

Also add the .cfg file:

```
generate_dynamic_reconfigure_options(
  cfg/parameters.cfg
)
```

And to prevent to first create the header file and than compile our node use:

```
add_dependencies(param_second ${PROJECT_NAME}_gencfg)
```

DYNAMIC RECONFIGURE

The level bitmask can be used to get what parameter has changed, edit the parameters.cfg file and set unique values to the level field

In the param_second.cpp callback add:

```
ROS_INFO ("%d",level);
```

To print the index of the label of the level value of the changed parameter